Top Quark Mass Measurement by DLM at CDF RunII

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Why Top Quark Mass ?

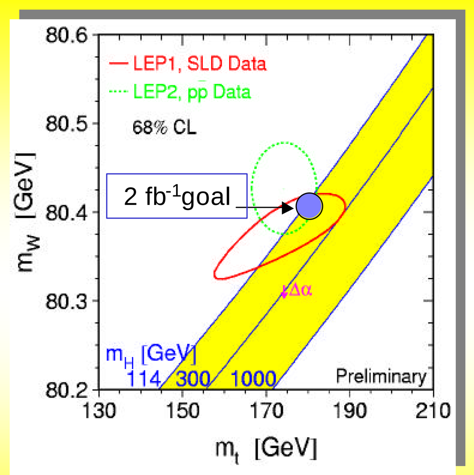
(1) Higgs boson mass constraint

(2) Setting the parameters of the (Non)Standard Model

c.f.) RunI CDF & D0 combined Mass

Published : 174.3 ± 5.1 GeV/c²

New(preliminary): 178.0 ± 4.3 GeV/c²



Remember the Tevatron is the only place which can produce top quark.

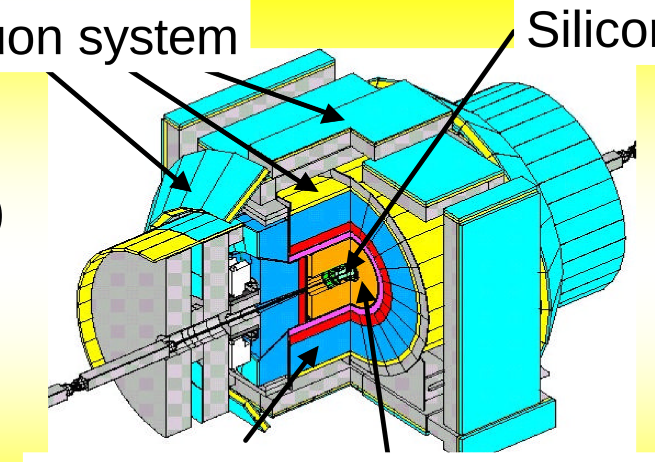
Data at CDF

Detector Upgrades

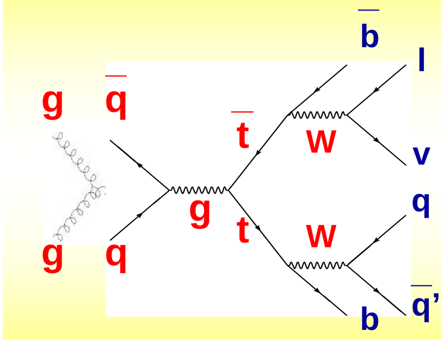
- New silicon tracker (|η|<2)
- New central drift chamber

CDF collected L=200 pb^{-1} from 2001 to 2003 Sep.

Already more than RunI !



Which Channel do we use?



Use "Lepton+jets" mode

1) One lepton : electron or muon
   Et(Pt) > 20 GeV, | η | < ~1.0
2) Met > 20 GeV
3) 4 jets : Et > 15 GeV, | η | < 2.0
4) At least 1 btag jets (SVX tag)

We observed 22 events from data of 162pb^{-1} (With silicon detector)

Dynamical Likelihood Method : Proposed in 1988 !

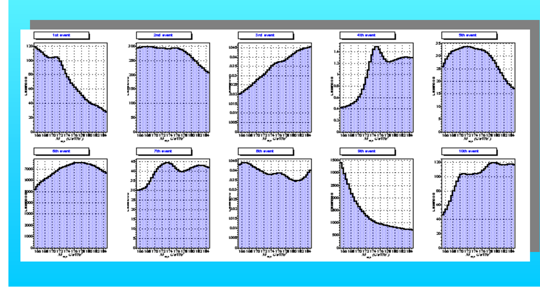
For i-th event **Likelihood is defined as,** *All combinations are summed up.

$$L^i(M_{top}) = \int \sum_{comb} \sum_{nsol} \frac{2p^4}{Flux} |\mathrm{M}|^2 F(z_1, z_2) f(p_t) w(\mathbf{x}, \mathbf{y}_t; a) dx$$

M : Matrix element of $t\bar{t}$ events, F, f : P.D.F. for z direction and P_T of $t\bar{t}$

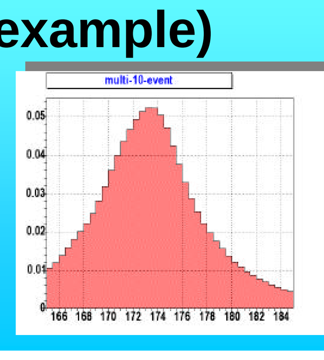
w : Transfer function, x ; partons ⟷ y ; observables(jets)

For all events **(Showing 10 events example)**

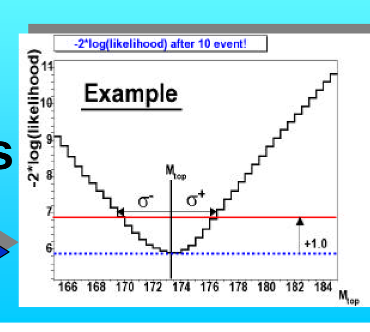


$$\prod L^i(M_{top})$$

event

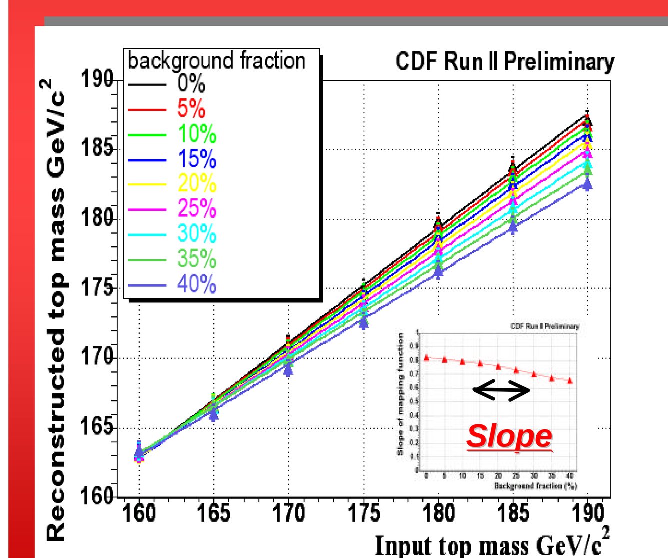


Take –2log to get errors



Background : How does it affect top mass?

If the sample includes background, likelihood peak is shifted down since it is multiplied.



- Need to correct this shift to extract the top mass. Left plot shows input mass vs reconstructed mass with varying background fraction[0-40%].
- Dominant background is nonW (QCD) events.

Background summary

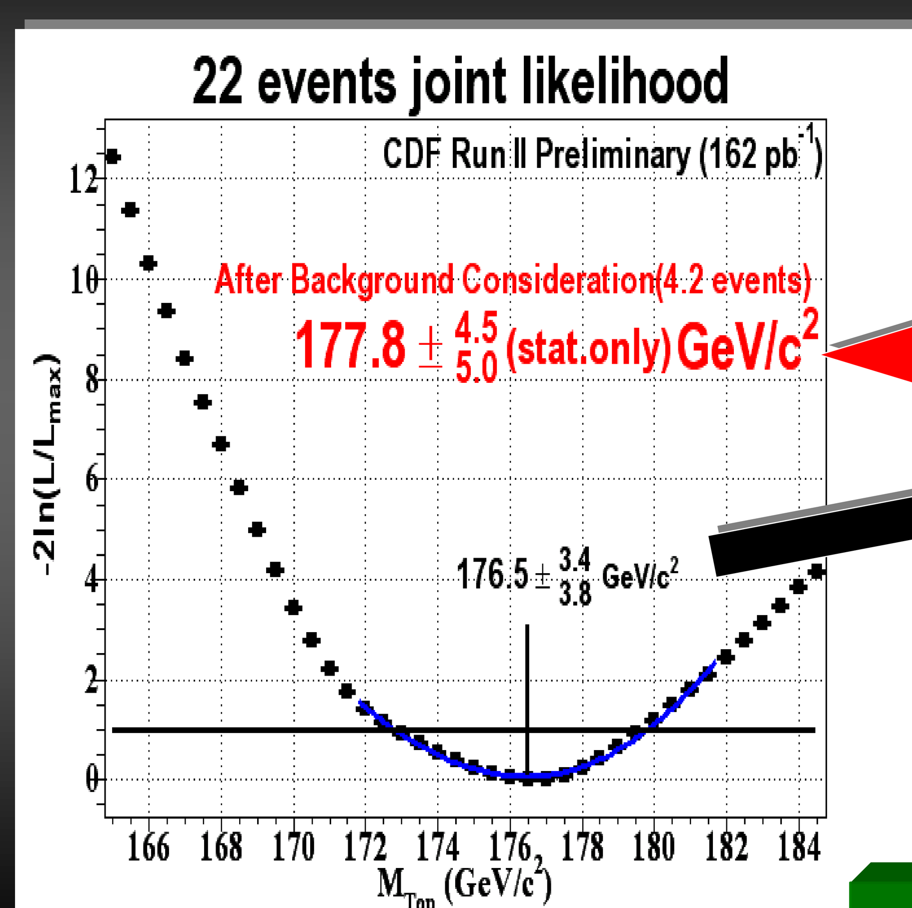
source	W+4j (NEV)
Mistag	1.2 ± 0.37
Wbb	0.7 ± 0.29
Wcc	0.3 ± 0.12
Wc	0.2 ± 0.12
Single top	0.17 ± 0.03
WW	0.08 ± 0.05
nonW	1.6 ± 0.38
Bkg total	4.2 ± 0.71
N observed.	22
tt (6.7pb)	20.9

Results

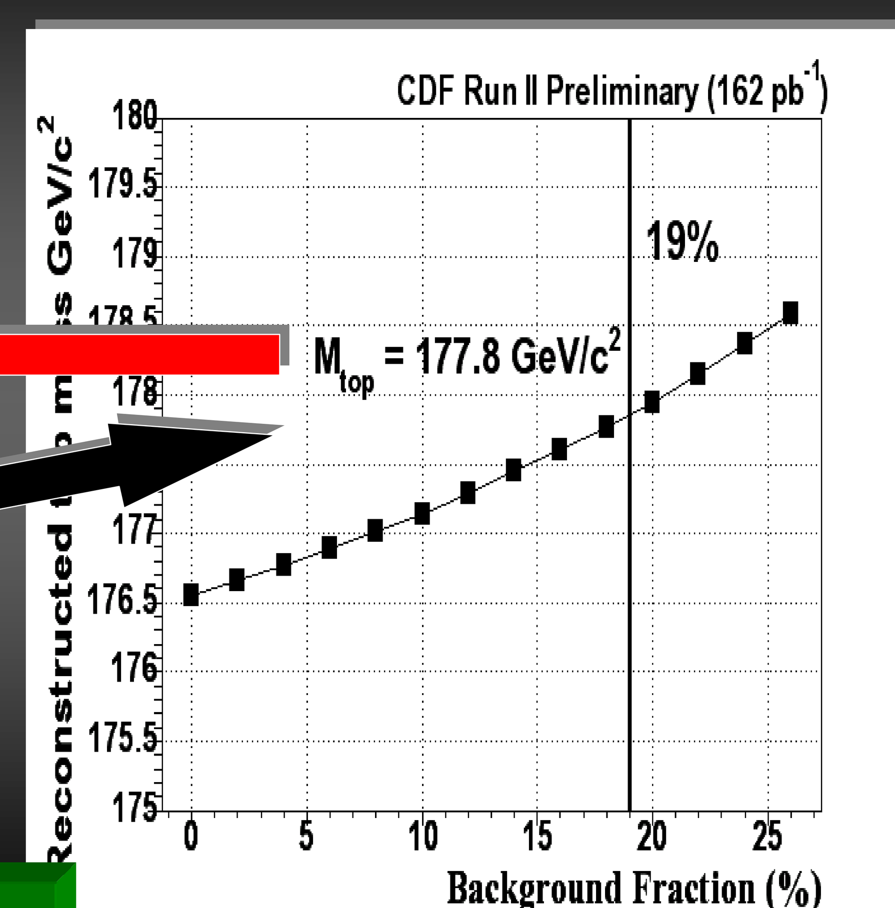
- Direct top mass value obtained from 22 observed events is 176.5 GeV/c². However, this Joint likelihood is affected by background-pulling. Therefore, background correction has to be done by using Mapping function.
- After taking into account shift due to 19% of the backgrounds, We obtain 177.8 GeV/c² as a final value.
- Statistical uncertainty is also scaled by the slope of the mapping function.

$^{+3.4}_{-3.8}$ → $^{+4.5}_{-5.0}$ GeV/c²

Extract top mass



Shift due to background

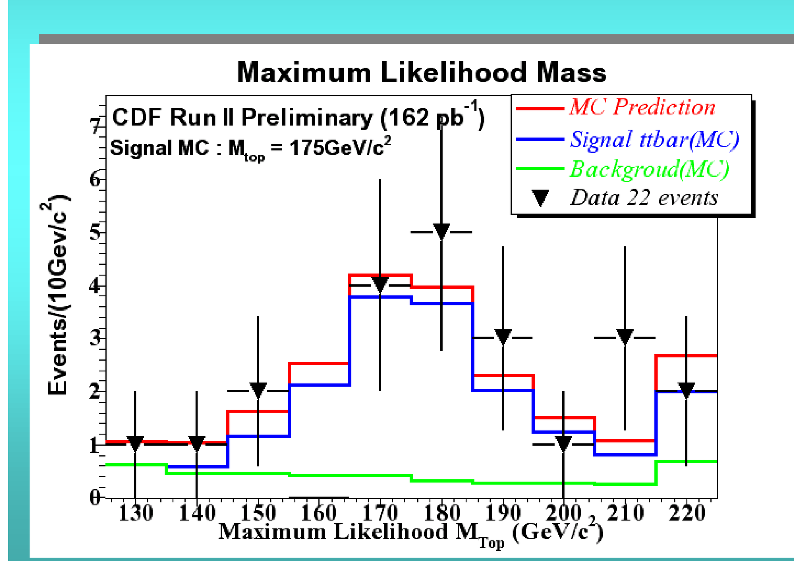


Background-pulling Correction

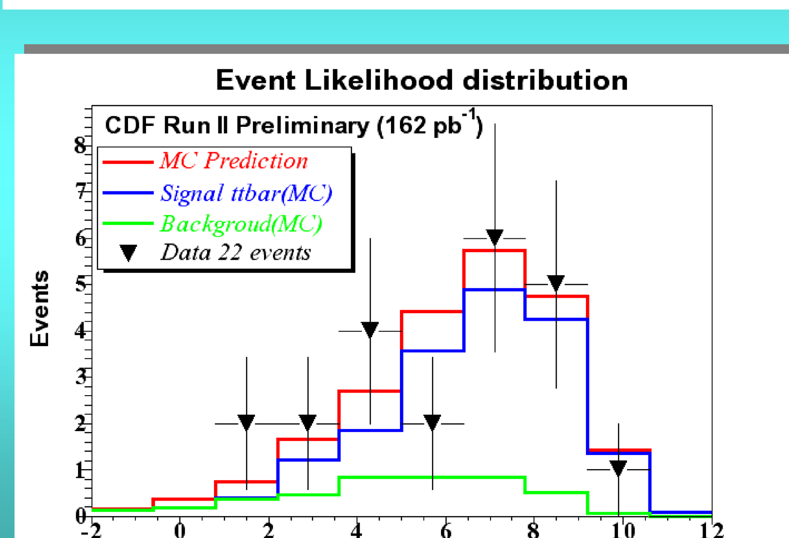
- Estimated number of background events is 4.2 events out of 22 observed events. **(19% background)**
- Left plot shows extracted top quark mass as a function of the background fractions between 0 and 25%.
- Mass shift due to background is within 1.5 GeV/c² up to 20% Background.
- The error of background fraction of 5% goes into systematic uncertainty

Various Checks & Systematic Error

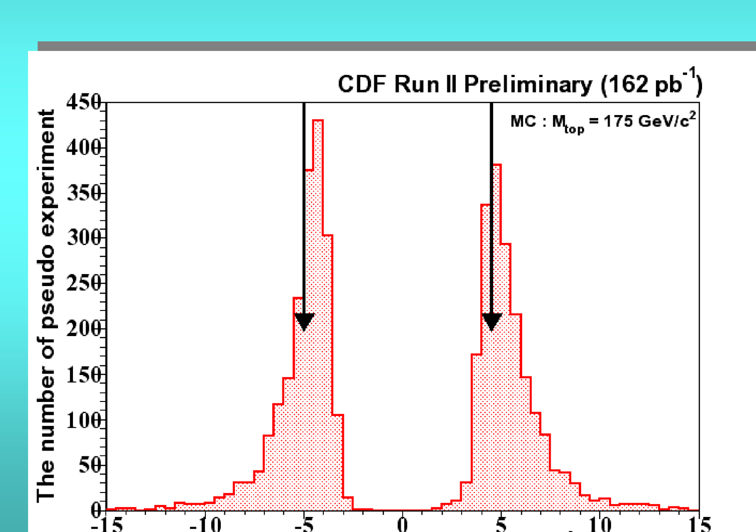
(1) : Event-by-event Maximum Likelihood Mass Signal M=175 GeV is used.



(2) : Event likelihood defined as, $L^i_{ev} = \int L^i(M)dM$



(3) : Expected Statistical uncertainty. Black arrows are those of data.



Systematic error Summary

Sources	Δ M_{top}(GeV/c²)
Jet Energy Scale	5.3
Transfer function	2.0
PDF	2.0
MC Generator/Model	0.8
ISR	0.5
FSR	0.5
Bkg fraction/Model	0.7
Spin correlation/NLO	0.6
Total	6.2

Conclusion : Top Mass = 177.8 $^{+4.5}_{-5.0}$ (stat.) ± 6.2 (syst.) GeV/c²

Currently MOST Precise Measurement in RunII

What's next ? Looking at future

(1) Precise measurement of the Top Quark Mass

- RunII goal is an error of 2-3 GeV including systematic uncertainty.
- Jet Energy Scale uncertainty is being improved by a better understanding of our simulation with great efforts!

Expectation : By only DLM single analysis

Time	Luminosity	stat. Error
Summer 2005	~ 600 pb^{-1}	~ 2.6 GeV
Summer 2006	~ 1 fb^{-1}	~ 2.0 GeV

(2) Beyond Mass Measurement & standard model

- The top mass can be used to determine top event full kinematics as a constraint in the likelihood, once we achieve a total error of 2-3 GeV!
- DLM is very powerful to look at the deviation from standard model ! Aim : New phenomena search associated with $t\bar{t}$ events

New Perspectives 2004, Fermi National Accelerator Laboratory, Batavia, Illinois, USA, 3rd-4th June. 2004

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